Lycoming Creek Follow-Up Investigation

Technical Report Prepared by Hedin Environmental through the Trout Unlimited AMD Technical Assistance Program TUTAG-03

June 2007

Background

This report in an addendum to a report submitted March 13, 2007 that presented the results of general stream sampling and focused on remediation recommendations for the primary source of AMD identified in the study area. Following the submittal of the original report, the Lycoming Creek Watershed Association (LCWA) requested additional field reconnaissance of the AMD site and better explanation of the distinction between acidification caused by historic mining activities and that caused by acid precipitation. This report provides this additional information.

Dutchman's Run Investigation

The Dutchman Run watershed was revisited in order to:

- Search for additional discharges
- Sample known and newly discovered discharges
- Determine if a definable stream exists above the Dutch03 discharge
- Identify locations for treatment system construction

One additional point source discharge was identified southwest of the Dutch03 discharge near the historical village of McIntyre. The discharge flows into the north-south trending hollow shown on the USGS map. Based on the mine mapping and visible subsidence features, it appears that the discharge flows from the No. 3 entry of the Miners Run Coal Company's E seam mine. Keeping with the numbering system adopted in the first report, the discharge is identified as Dutch04. The water quality of this discharge is more acidic than Dutch03 (100 mg/L vs 50 mg/L), but because the flow was only 2-3 gpm, the acidity loading was only about 5% of Dutch03.

The June 4 reconnaissance occurred after thunderstorms had soaked the area. In addition to the primary Dutch03 discharge, seepage areas were observed in the headwaters of Dutchman's Run. These flows were acidic and chemically similar to Dutch03. The seeps appear to be leakage from the deep mine not captured by the flume or the Dutch03 flow that has infiltrated into spoil and reemerged downgradient.

It is likely that a portion of this diffuse seepage results from the fact that the deep mine heading from which the Dutch03 discharge flows is obstructed by spoil. The spoil has impounded water in the mine forming a pool. This pool leaks though the coal outcrop and strip mine spoils over a large area, forming diffuse seeps. Installing a collection system that dewaters the mine and provides a controlled outlet for flow could reduce the flows at these seeps. Logically the collection system would collect more AMD than is currently captured by the flume. A proportional modification to the size of the treatment system would be necessary.

One concern raised by DCNR personnel was that the USGS mapping shows Dutchman Run flowing above the AMD discharge area. Past reconnaissance activities suggested that the mapping was incorrect and that there is not a permanent stream flowing above the AMD. The June investigation confirmed this. No definable stream was found above the Dutch03 discharge. All flow in the poorly defined channel could be traced back to the Dutch03 discharge or to other small AMD seepage areas nearby.

An area of spoil piles exists downslope of the Dutch03 discharge. This AML area comprises at least 10 acres. These spoil piles could be regraded and reclaimed to create space for a treatment system. One option for spoil disposal would be used it to reclaim highwalls adjacent to the discharge. Utilizing the area currently occupied by spoil piles would allow for construction of a treatment system without disturbing unmined adjacent forests.

The value of the spoil piles as fuel for a fluidized bed power plant was of interest. Power plants burn waste coal and high BTU shale. The plants do not burn overburden spoil that is produced from the weathering of shale, siltstone, and sandstone. All of the piles observed in June were overburden. LCWA was aware of a refuse assessment conducted by DEP two summers ago. HE contacted DEP personnel at the Cambria BAMR office and at the Moshannon District Mining Office. The sampling was done by BAMR at the request of the Moshannon DMO. The opinion of the DEP, at this time, is that the McIntyre Mountain mines do not have valuable coal refuse reserves. The contact for LCWA on this matter is Mario Carrello at the Moshannon DMO.

Proceeding with an AMD Remediation Project

The information provided in the original report provides a solid base for the eventual design and construction of a passive system at the Dutchman Run. The chemistry of the AMD has been reliably characterized. The primary flow has been reliably measured below the primary discharge point. A conceptual treatment system has been designed and sized based on the data and is described in the March 13, 2007 technical report by Hedin Environmental. There is a large excess of suitable construction acreage on AML land below the discharge. There is support for a project at the Moshannon District Mining Office and there appears to be support at DCNR. Finally, funds to construct a passive treatment system are currently available through the Growing Greener Programs and additional funds will soon become available through BAMR's Title IV AML Program.

A Phased approach to the Project is recommended:

Phase I: Develop the Project Team and Implementation Strategy

- Engage the Moshannon District Mining Office in the project. This office will be able to develop a funding strategy that LCWA can pursue.
- Engage the DCNR. DCNR priorities as land managers can clash with the Growing Greener's emphasis on construction projects. The classification of the AMD area as a Wild Area could complicate construction plans. LCWA should request that DCNR develop a process that will allow the installation of a treatment system, while including DEP as a partner.
- Prepare and submit a grant proposal to implement Phase II. DEP can guide the LCWA through this process.

Phase II: System Design

- Site Assessment and Survey: A survey will need to be completed that delineates AML from native un-mined forests. Wetlands, stream channels and archeological features should be identified. This inventory and map will be used to set project boundaries.
- AMD Collection: The AMD should be collected into a pipe. The primary discharge point should be excavated down to the bottom of the coal and a drain installed. The system is expected to collect more water than is currently discharging through flume, but also eliminate non-point seepage in the area. The flows and chemistry should be monitored as long as possible (at least six months)
- System Design: A treatment system should be designed that is sized for the collected flow and chemistry and is located in an area approved by DCNR. The deliverable should be a biddable construction package and cost estimate.
- Project Permits: Permits should be obtained for the project.
- Grant Submittal: A grant proposal should be prepared for the project's construction and follow-up monitoring (12 months). DEP should guide the LCWA through this process.

Phase III: Construction and Monitoring

- Bidding: The project should be bid and a contractor selected.
- Construction: The project should be constructed. Inspection by qualified personnel should occur. LCWA and DCNR should recognize that minor changes to construction plans are common for projects on AML sites
- Monitoring: The treatment performance of the system and its impact on Dutchman Run should be monitored. A good baseline for the post-project conditions can be achieved with monthly monitoring. Assuming good results, the monitoring can be decreased to quarterly.

Acid Mine Drainage vs. Acid Deposition – The Basics

Acid mine drainage (AMD) and acid deposition (often referred to as "acid rain") can have similarly negative effects on poorly buffered streams. AMD results from the oxidation of sulfide minerals found in the rocks overlying the coal and in the coal itself. The oxidation process produces sulfuric acid and dissolved iron (Fe). This acidic solution can dissolve other minerals releasing additional metals such as aluminum (Al) and manganese (Mn). The net result is an acidic solution containing elevated sulfate and various concentrations of Fe, Al, Mn, Ca, and Mg. Acidity, Al and Fe are the parameters that make mine drainage toxic. If this acidic flow contacts alkaline strata such as limestone or dolomite, the acidity can be neutralized and the mix of metals is modified. The toxicity is lessened, but not always eliminated. Sulfate is not generally affected by these reactions. Most mine drainages have sulfate concentrations that are measured in hundreds or thousands of mg/L. Streams strongly affected by mine drainage also have high sulfate concentrations – generally greater than 100 mg/L. Luckily, sulfate at these concentrations is not toxic to most aquatic life.

Acid deposition results from air pollutants such as sulfur dioxide and nitrogen oxides. The source of the sulfur dioxide is sulfur contained in the coal – the same sulfur that can produce AMD. Nitrous oxides are produced during the combustion process. These gases react with water in the atmosphere to form weak sulfuric and nitric acid. The result is precipitation that is more acidic than occurs in the absence of these acids.

The Penn State Institutes of the Environment has been studying acid precipitation in PA for the last ten years[1]. The closest station to Lycoming Creek is Little Pine Creek in western Lycoming County. Rainfall at this station (as everywhere in PA) was found to be acidic. Table 1 shows the average characteristics of rainfall in Little Pine Creek in 2004 (the latest data presented in the report). Table 1 also shows the chemistry of an AMD discharge in the Dutchman Run watershed. The AMD is 25 times more acidic and has 50 times more sulfate than the acid precipitation.

Table 1. Rainfall Characteristics in Little Pine Creek watershed (Lynch et al., 2005) and AMD characteristics for Dutch 03 in the Lycoming watershed (this report)

Parameter	Acid Precipitation	AMD (Dutch 03)
pH	4.4	3.4
Acidity, mg/L as $CaCO_3$	2.2	53
Sulfate, mg/L	2.8	133

[1] Lynch, J. Carrick, H., Horner, K. and J. Grim. 2005. Reductions in Acidic Wet Deposition Following Implementation of the Clean Air Amendments of 1990: 1995 – 2004. Penn State Institutes of the Environment. University Park, PA.

Acid precipitation is a very dilute solution and can be readily neutralized by alkaline soils. In western and central PA where many soils are derived from alkaline strata, acid precipitation has no effect on stream water quality. However, in areas where the soils and bedrocks are not alkaline, the acidity is not quickly neutralized and it can retain its low pH and dissolve soil minerals that release aluminum. The streams that receive un-buffered acid precipitation have low pH and low, but ecologically significant, concentrations of Al.

AMD vs Acid Rain in the Middle Lycoming Creek Watershed

Both AMD and acid precipitation can acidify streams. In sensitive regions where there is limited acid buffering capacity, distinguishing acid rain and acid mine drainage degradation is important because remediation strategies and funding sources differ for the problems. Lycoming Creek falls into this category because its buffering capacity is so limited in the middle watershed. Sulfate concentrations are a good indicator for distinguishing AMD and acid rain. Sulfate concentrations in AMD are typically 50 -500 times higher than sulfate concentrations in acid precipitation. Streams severely impacted by AMD commonly have instream sulfate concentrations of 100 – 1000 mg/L. A stream acidified with acid precipitation will have instream sulfate concentrations less than 30 mg/L. These generalizations can vary because of natural sources of non-acidic sulfate that may provide a higher background level than higher than 30 mg/L. If sulfate concentrations are being used to make important remediation decisions, the background sulfate levels should be determined by sampling streams that are known to NOT have any mining history.

Table 2 shows chemical analyses for streams in the Lycoming watershed that were sampled for this project. The influence of AMD on Dutchman Run is evident from the elevated sulfate concentrations. A good secondary indicator of AMD in this watershed is conductivity. AMD impacted water has significantly higher conductivity than non-AMD impacted waters.[2]

The other tributary streams are also characterized by acidic conditions. Because sulfate concentrations are very low for these streams, AMD cannot be inferred as the acidification source. The acidic conditions in these streams are likely due to acid precipitation and, perhaps, natural acidification processes. Sphagnum wetlands can acidify waters, creating low pH conditions. We were informed that the Rock Run headwaters originate in a large wetland. The acidic conditions present in this stream may be due to the wetland.

Lycoming Creek in Trout Run is weakly net alkaline. The negative acidity indicates that the stream has acidity neutralization capacity. Based on the sampling of tributary streams in the Ralston area, the source of the alkalinity is unlikely to be in the rugged middle watershed. The upper watershed, which is more agricultural, may be the source of alkalinity.

[2] A good tool for distinguishing acid rain and AMD impacts in this watershed is the Hanna HI 98129 waterproof conductivity, pH, and temperature meter.

Table 2. Chemistry of streams in the Ralston area of Lycoming Creek.

Point	Date	pH	Cond	Alk	Acid	Fe	Mn	Al	SO4
Yellow Dog Run	Dec 06	5.0	25	1	8	<0.04	0.05	0.18	***6***
Hound Run	Dec 06	5.4	27	2	4	<0.04	0.31	0.20	***7***
Miners Run	Dec 06	4.9	30	1	7	<0.04	0.11	0.36	***8***
Little Gap Run	Dec 06	6.1	73	4	2	<0.04	0.09	0.17	***20***
Frozen Run	Dec 06	5.4	28	2	5	0.08	0.05	0.26	***8***
Red Run Mouth	Dec 06	4.9	54	1	8	<0.04	0.23	0.43	***15***
Rock Run Headwater	Dec 06	4.5	38	0	23	0.12	0.05	0.50	***8***
Rock Run Above Mining	Dec 06	6.2	37	6	-1	<0.04	<0.02	0.16	***6***
Rock Run Above Hound Run	Dec 06	6.2	39	6	-1	<0.04	<0.02	0.10	***6***
Dutchman Mouth	Nov 06	3.4	308	0	49	0.85	1.10	3.35	***102***
Dutchman Mouth	Apr 06	3.5	362	0	50	0.95	1.26	3.37	***200***
Lycoming (Trout Run)	Jun 07	6.0	77	16	-10	0.04	0.04	0.31	***11***

Conductivity is uS; other parameters are mg/L; acidity and alkalinity as $CaCO_3$

Lycoming AMD compared to AMD Statewide

In comparison to AMD sites elsewhere in Pennsylvania, the AMD found in the Dutchman's Run watershed is mild. Table 3 compares the Dutch03 discharge to two other mine discharges in north central Pennsylvania. The Hunters Drift Discharge is located in the Babb's Creek watershed in Tioga County. The MB-R2 discharge is located in the lower Kettle Creek watershed in western Clinton County. The severity of AMD is generally assessed by considering the acidity, aluminum, and iron concentrations. All of these parameters are at least 10 times higher in the Babb Creek and Kettle Creek discharges.

Table 3. Comparison of Dutch03 discharge to Babb's Creek Discharges

	Dutch03	Hunters Drift	MB-R2
Flow (gpm)	254	278	45
pH	3.4	2.8	2.8
Acidity (mg/L as $CaCO_3$)	53	491	737
Iron (mg/L)	1	44	21
Aluminum (mg/L)	3	36	87
Manganese (mg/L)	<1	32	20
Sulfate (mg/L)	133	471	889

This comparison does not negate the environmental impact of the Dutch03 discharge. Because Dutchman Run is so weakly buffered, this "weak" AMD has devastating effect on stream ecology.

A positive aspect of Dutch03's mild AMD chemistry is that it is well within the capabilities of passive treatment. There is little doubt that a properly designed passive system can provide years of treatment with minor operation and maintenance requirements.

Acid Mine Drainage vs. Acid Rain – Implications for Lycoming Creek

As described in the previous section, the acidic quality of precipitation is well documented in north central Pennsylvania. Using the concentrations of acidity and sulfate found in Table 1 some basic comparisons are made between the impacts on Lycoming Creek from AMD in Dutchman's Run and acid deposition. Table 4 shows assumptions and calculations. On average, the annual precipitation in the watershed is 712 million gallons of water per square mile. Using the average acidity content of 2.2 mg/L (Table 1), the acidity deposition rate is calculated at 6.5 tons ($CaCO_3$) per square mile per year.

Table 4. Comparison of acid contributions from Dutch03 and acid deposition

Average Precipitation	41 inches per year
Average Precipitation	712,478,976 gallons per square mile per year
Acidity	6.5 tons per year per square mile (as $CaCO_3$)
Watershed area above Ralston	75 square miles
Acid deposited above Ralston	487 tons per year (as $CaCO_3$)
Dutchman Run watershed	1.4 square mile
Acid deposited to Dutchman watershed	9 tons per year (as $CaCO_3$)
Acid load from Dutch03	21 tons per year (as $CaCO_3$)

The Dutchman Run watershed is about 1.4 square miles. In an average year, acid deposition deposits 9 tons acidity in the watershed, while the Dutch03 discharge releases 21 tons. The AMD problem is obviously intense and severe on this level. As the geographic scale increases, the relative significance of AMD becomes less and acid precipitation dominates. This is because mining and AMD is quite localized in the watershed. The Lycoming Creek watershed above Ralston receives 487 tons acid/year or 23 times more acidity from acid deposition than is produced by the Dutch03 discharge.

These same calculations can be used to determine how much acid deposition could be neutralized by treatment of the Dutch03 discharge. If the passive treatment system has a discharge with net alkalinity of 100 mg/L, then 56 tons of excess alkalinity will be added to Lycoming Creek. This amount of alkalinity would offset the acid deposition on 9 square miles of the watershed or about 11% of the watershed area above Ralston. If the buffering capacity consumed by the acid input of the untreated discharge is considered as well, the area offset increases to 16%.

Funding Opportunities for Remediation Projects

Congress recently reauthorized Title IV of the Surface Mine Reclamation and Control Act . The Act committed several billion dollars of funding for abandoned mine land (AML) reclamation and AMD treatment that will be spent over the next 15 years. Pennsylvania's share is about $1.4 billion. The program's priorities are reclamation projects that eliminate hazardous conditions such as highwalls, water-filled pits, mine fires, steep unstable slopes, etc. During our inspections of the McIntyre Mountain AML area, we only saw a few small areas with a hazardous highwall conditions. Nonetheless, the large increase in funding should make reclamation of AML in the watershed possible, if the LCWA and DCNR pursue it.

The reauthorization also increased the amount of funding that could be spent on AMD. In addition to possible funding from the Title IV AML Fund, the Growing Greener Program also provides funds for AML reclamation and AMD remediation.

The Title IV AML funding cannot be spent on acid precipitation problems. The LCWA will need to find other funding sources for water quality problems above Ralston.

Recommendations

Lycoming Creek and its tributaries are degraded locally by AMD and watershed-wide by acid precipitation. This study characterized AMD sources on McIntyre Mountain. The AMD is mild and can be treated with reliable passive techniques. The systems could be built on existing AML with limited impact to the surrounding forests. Funding opportunities exist for AMD remediation projects. LCWA should pursue these opportunities.

Lycoming Creek is a poorly buffered stream. In the Ralston area, every stream sampled was acidic. Very low sulfate concentration in these tributary streams and Lycoming Creek point to acid precipitation as the primary acid source. An assessment should be conducted that determines an acidity/alkalinity balance for the watershed. Sources of alkalinity that are currently buffering acidic inflows in the middle watershed should be identified. Methods of mitigating the acidification of the streams in the Ralston area should be investigated.

Table 5. Laboratory results for samples collected June 4, 2007 by Hedin Environmental and LCWA.

SAMPLE ID	Sample	Field	Lab	Cond.	Alk.	Acid	Fe	Mn	Al	SO_4
-	Date	pH	pH	Umhos	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
D-03A	04-Jun-07	3.5	3.3	384	0	54	10.8	1.3	2.6	78
D-03	04-Jun-07		3.4	290	0	50	0.8	0.5	2.8	72
TRIB into Dutchman	04-Jun-07		4.0	165	0	24	0.2	1.5	2.2	51
McIntyre Mine AMD	04-Jun-07	3.0	3.0	586	0	109	7.3	0.6	4.7	114
Pond on Miners Run	04-Jun-07	4.5	4.9	24	1	6	0.4	0.3	0.3	10
Lycoming Creek in Trout Run	04-Jun-07	6.5	6.0	77	16	-10	0.0	0.0	0.3	11